# SYSTEM DEVELOPMENT POWERHOUSE

**This presentation offers National Defense Industrial Association (NDIA) Systems Engineering Conference occurring October 20-23, 2003 at the Hyatt Regency Ilandia Hotel in San Diego, California is a portion of a four hour presentation (a subset of an 18 day system engineering course of study) covering the four fundamental areas of excellence required for an enterprise to satisfy the representation title.**

**Jeffrey O. Grady**
**President**
**JOG System Engineering, Inc.**
**6015 Charae Street**
**San Diego, CA 92122**
**(858) 458-0121**
**jeff@jogse.com**
**http://www.jogse.com**

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# Who Is Jeff Grady?

## CURRENT POSITION

President, JOG System Engineering, Inc.
System Engineering Assessment, Consulting, and Education Firm

## PRIOR EXPERIENCE

1954 - 1964 U.S. Marines
1964 - 1965 General Precision, Librascope Div
- Customer Training Instructor, SUBROC and ASROC ASW Systems

1965 - 1982 Teledyne Ryan Aeronautical
- Field Engineer, AQM-34 Series Special Purpose Aircraft
- Project Engineer, System Engineer, Unmanned Aircraft Systems

1982 - 1984 General Dynamics Convair Division
- System Engineer, Cruise Missile, Advanced Cruise Missile

1984 - 1993 General Dynamics Space Systems Division
- Functional Engineering Chief & Manager, Systems Development
- Advanced Projects Systems Engineering

## FORMAL EDUCATION

BA Math, SDSU
MS Systems Management, USC with Information Systems certificate

**INCOSE** Fellow, Founder, First Elected Secretary

**AUTHOR** ***System Requirements Analysis, System Integratio***
***Validation and Verification, System Engineering Planning***
***Enterprise Identity, System Engineering Deployment***


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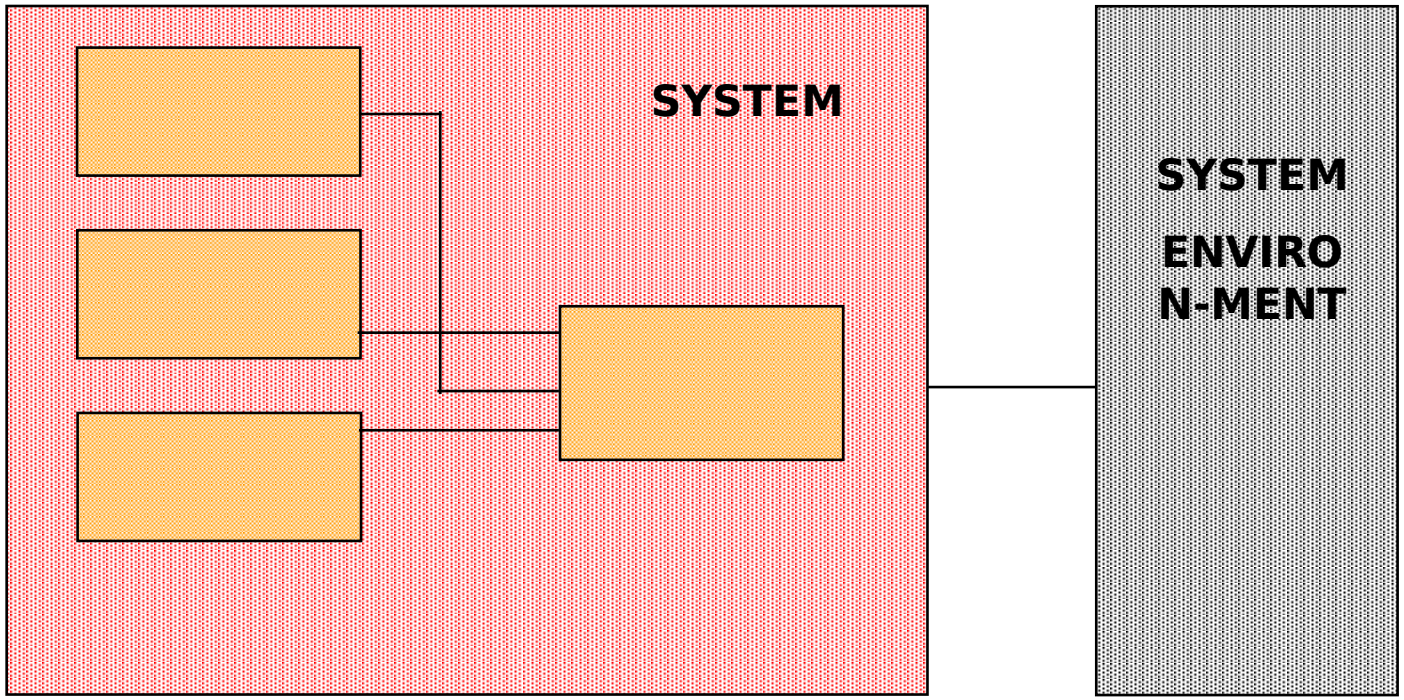
# First, what is a system?




**A collection of entities that interact through relations to achieve common purpose.**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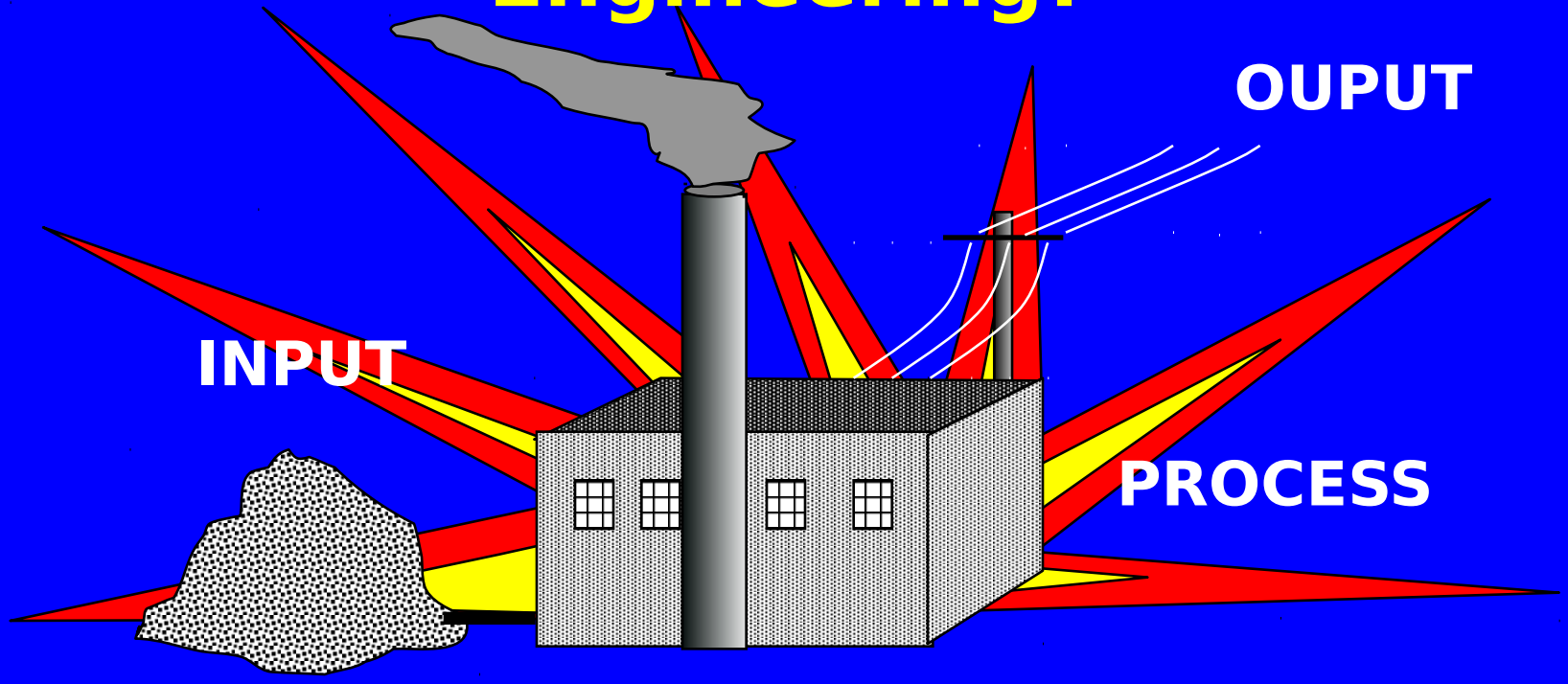
# Is Your Company a Powerhouse of System Engineering?




Or is it only wishful thinking that it could be.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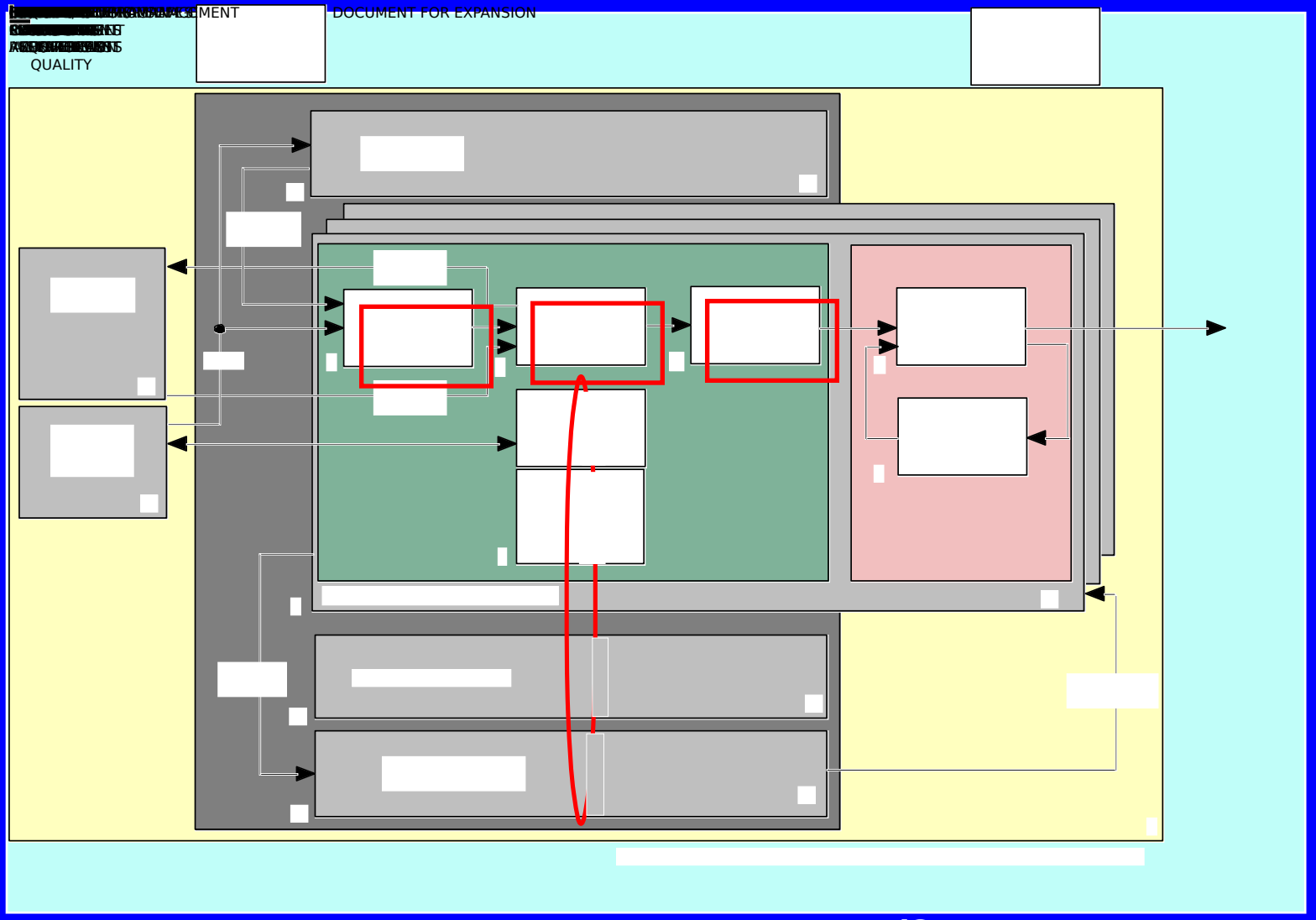
# The Answer is in the Process

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# The Simple Secret to Successful System Development

- Define the problem
- Synthesize a solution
  - Engineering design
  - Acquisition of material
  - Manufacturing
- Prove that the solution satisfies the requirements
- Accomplish all three steps within the context of a sound management infrastructure


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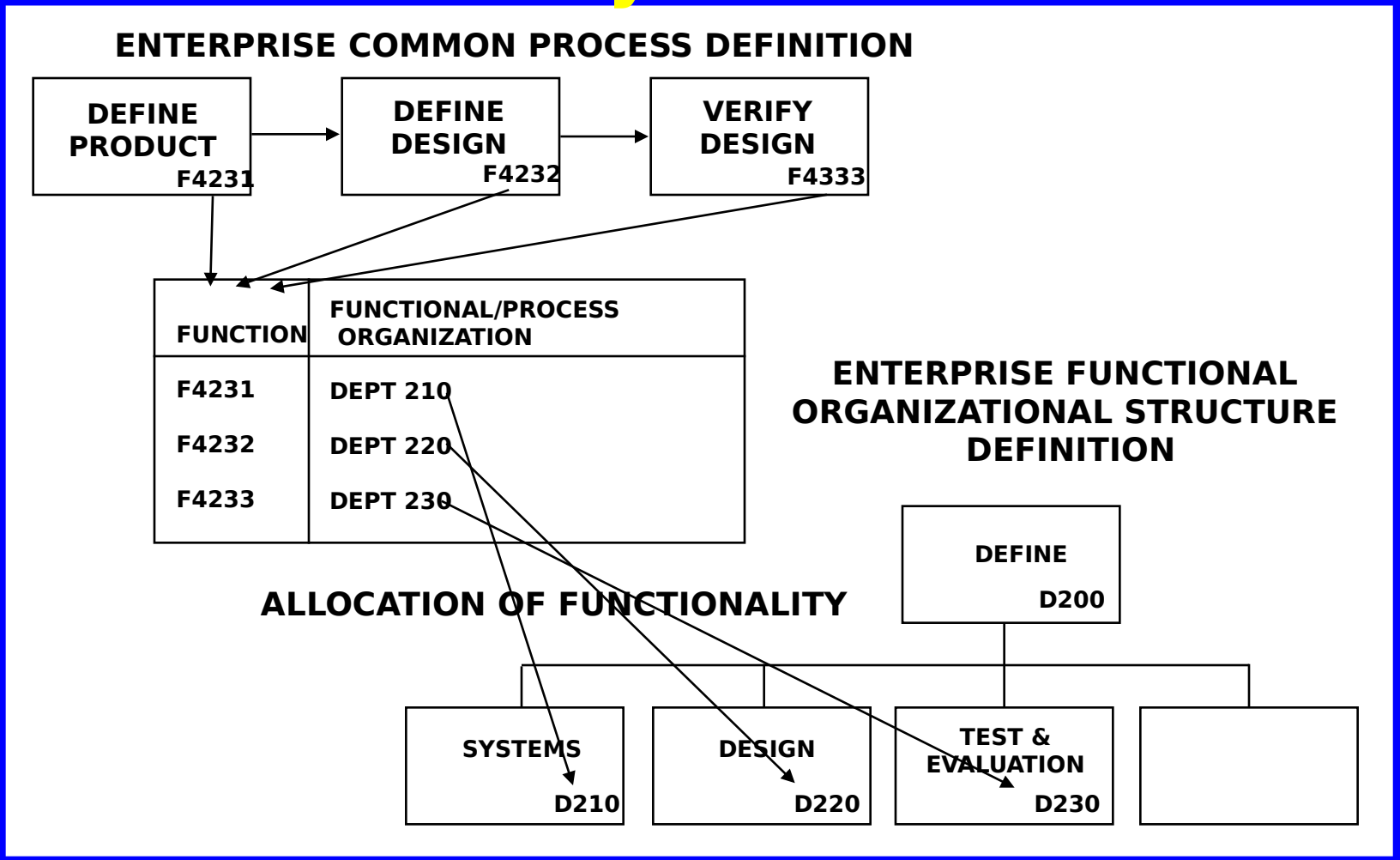
# Engineer Your Enterprise as a System





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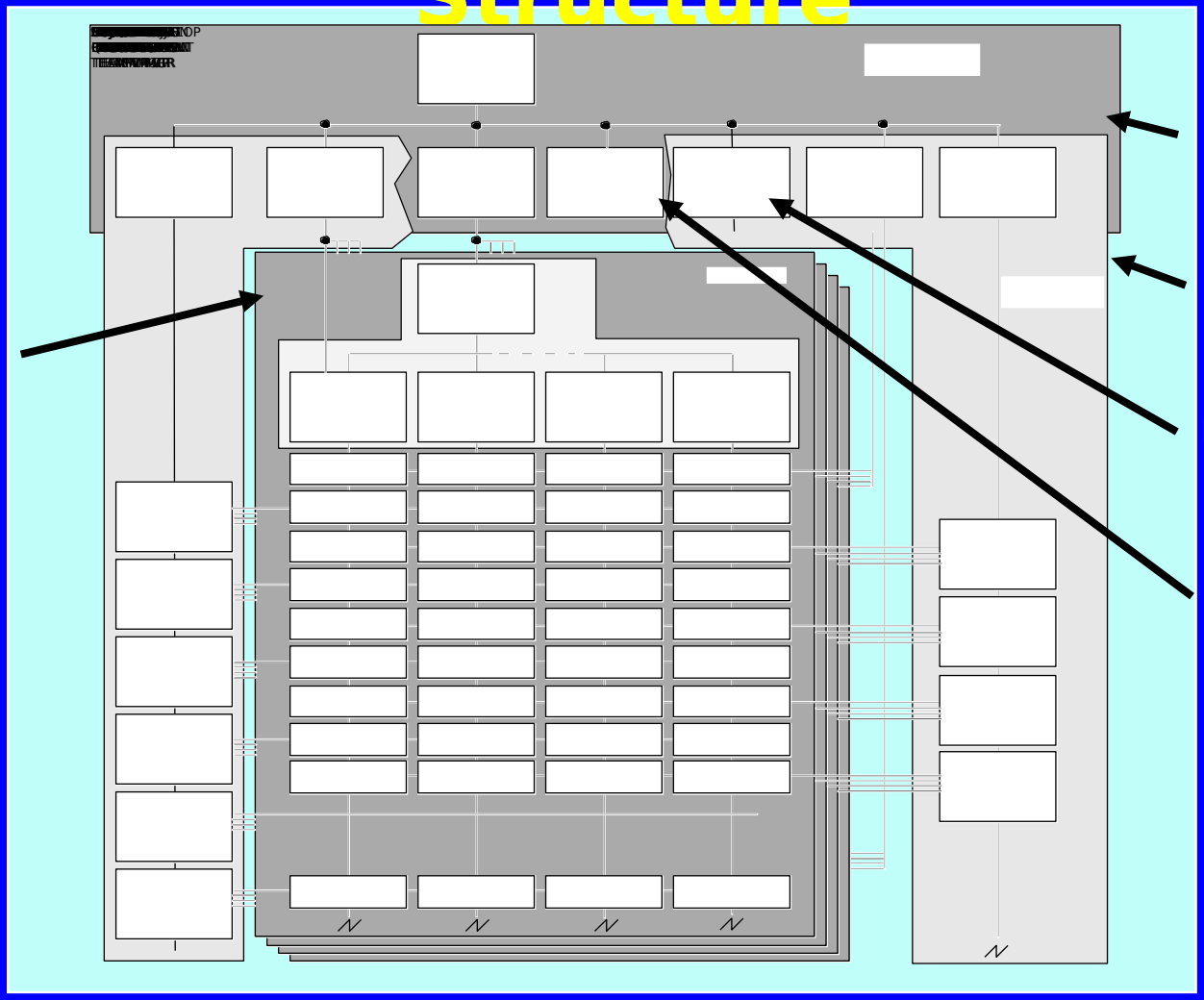
# The Five Enterprise Functions Mapped to an Organization Structure



PERFORM ENTERPRISE BUSINESS

MANAGE THE ENTERPRISE

PROVIDE PROGRAM RESOURCES

ASSURE PRODUCT AND PROCESS QUALITY

ACUIRE NEW BUSINESS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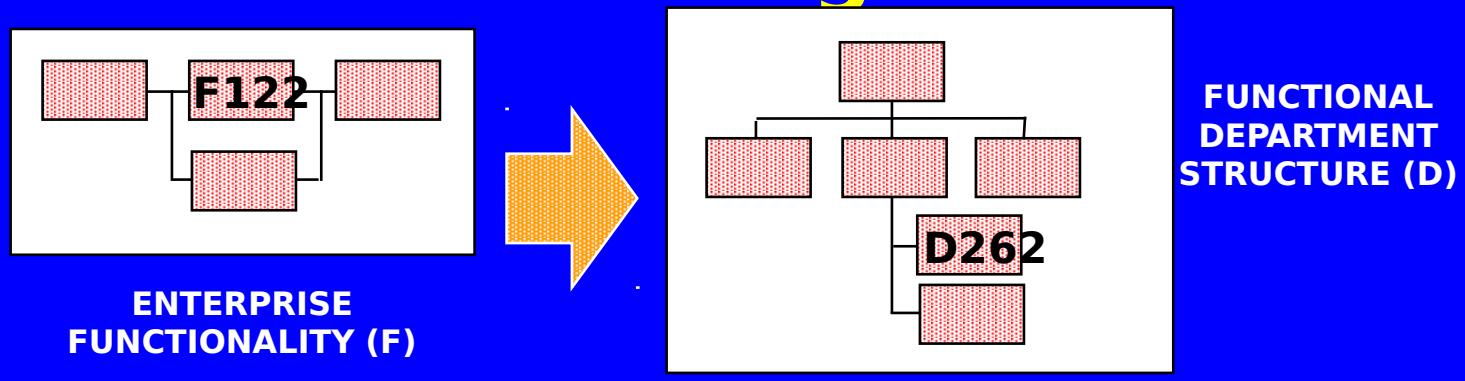
# Functional Planning Structures, F-Strings




- F122-D262 IDENTIFIES A UNIQUE ELEMENT OF WORK
- PLANNING LEVEL GRANULARITY
- BEWARE OF EXCESSIVE PLANNING DETAIL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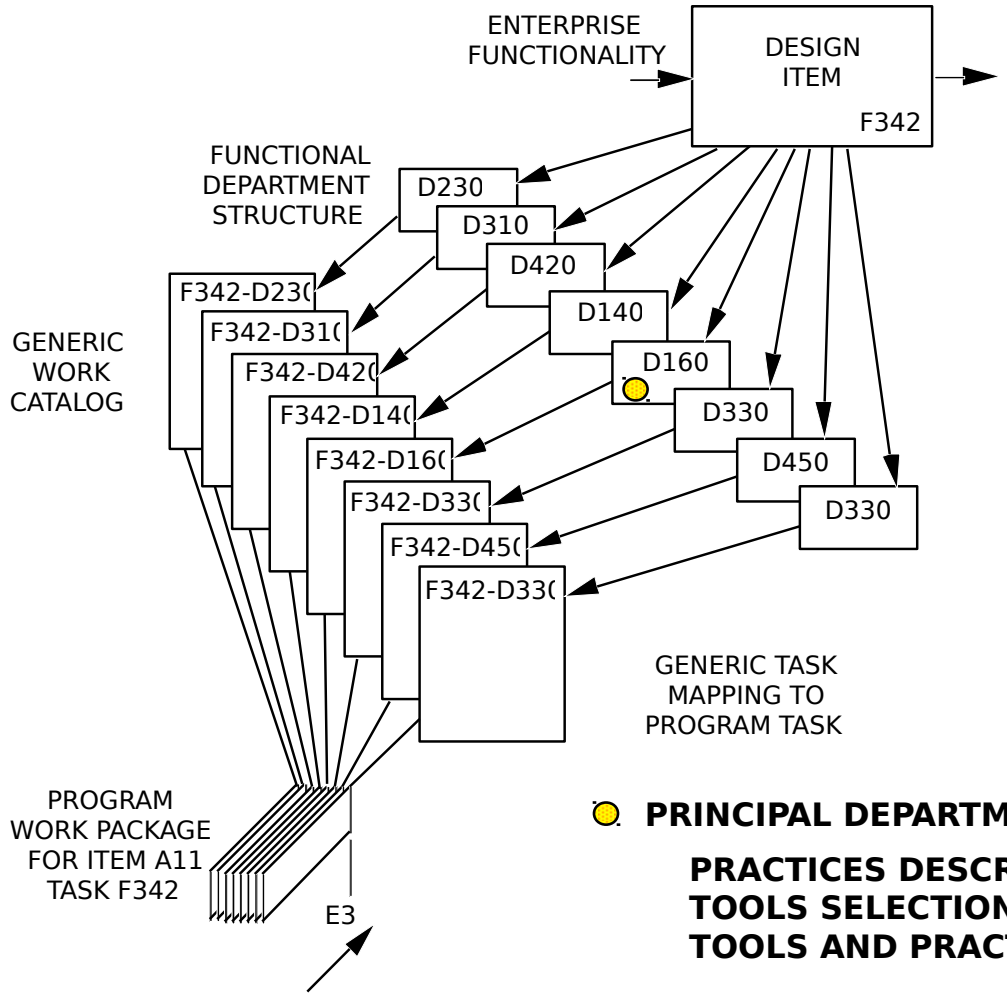
# Primary Task Responsibility





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# Program Planning Strings, P-Strings

- **PROGRAM IDENTIFICATION (P)**
  - PERMITS COMPREHENSIVE ENTERPRISE DATABASE
- **PROGRAM PHASE/STAGE (S)**
  - COORDINATES COMMON PROCESS WITH CUSTOMER PROGRAM PHASING
- **PROGRAM EVENTS (E)**
  - FITS WORK INTO TIME AXIS
- **PROGRAM ARCHITECTURE (A)**
  - LINKS PLANNING TO PRODUCT
  - LINKS PLANNING TO IPD TEAMS

**P05-S01-E03-A12**


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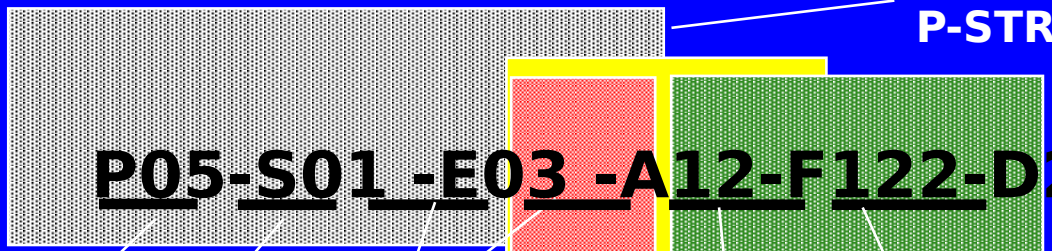
# Typical Composite Planning String




PROGRAM P-STRINGS

ENTERPRISE F-STRINGS

ENTERPRISE PROGRAM 05

PROGRAM PHASE 01

PRODUCT WBS/ARCHITECTURE ITEM A12

PROGRAM EVENT 03

- E00 CONTRACT AWARD
- E01 SYSTEM REQUIREMENTS REVIEW
- E02 SYSTEM DESIGN REVIEW
- E03 PRELIMINARY DESIGN REVIEW
- E04 CRITICAL DESIGN REVIEW
- E05 FUNCTIONAL CONFIGURATION AUDIT
- E06 PHYSICAL CONFIGURATION AUDIT

FUNCTIONAL DEPARTMENT SUPPLYING PERSONNEL DOING PROGRAM WORK (SEE EDD APPENDIX C)

PROCESS (SEE EDD APPENDIX A)

SOW (INITIAL PLANNING STRINGS)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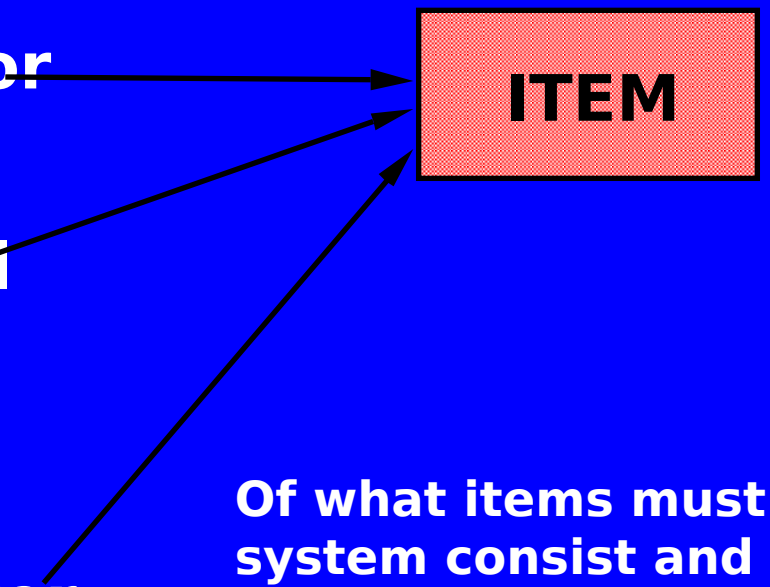
# Define Product Requirements - Requirement Defined

- Something wanted or necessary.
- Something essential to the existence or occurrence of something else.
- A necessary characteristic or attribute of some thing (or item).




**Of what items must a system consist and how can I communicate needed characteristics for those items to designers?**

**REQUIREMENTS ARE THE ANSWER!**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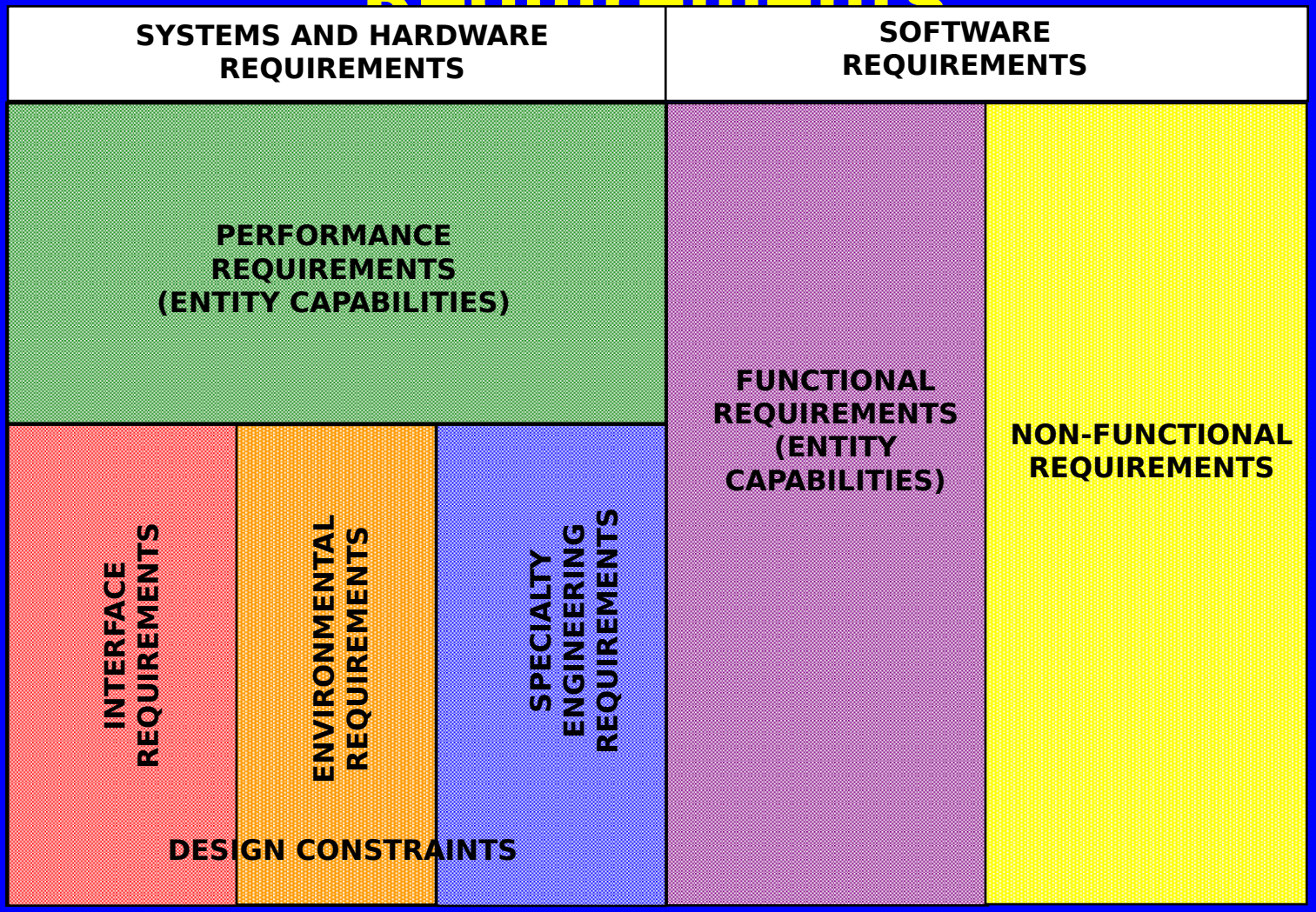
# Kinds of Product Requirements





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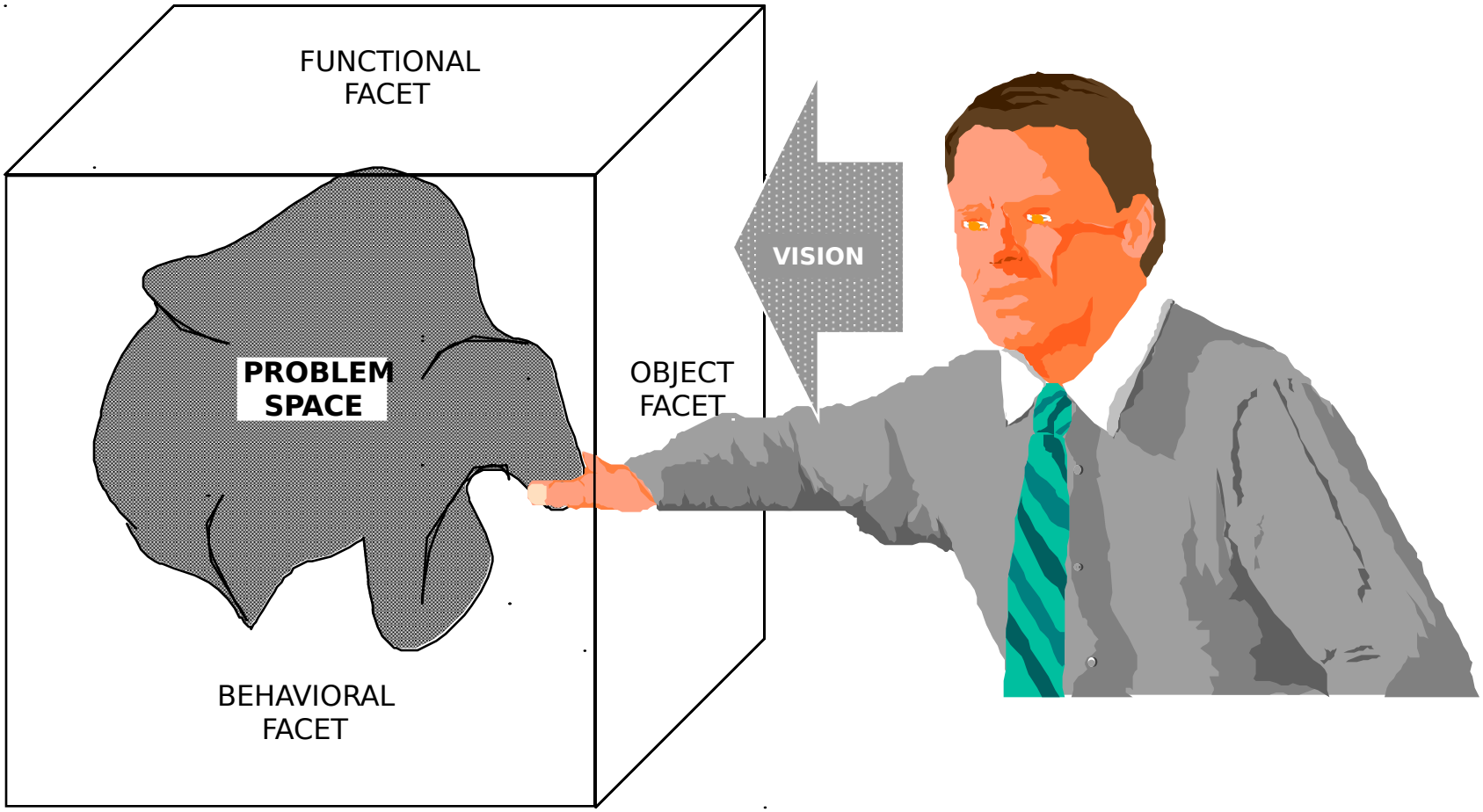
# Use Structured Analysis to Understand Problem Space

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# Systems and Hardware Structured Analysis Models

- Traditional structured analysis
  - Flow diagramming
  - Enhanced flow diagramming
  - Behavioral diagramming
  - IDEF-0
  - Process diagramming
- State diagramming
- FRAT
- Quality function deployment (QFD)


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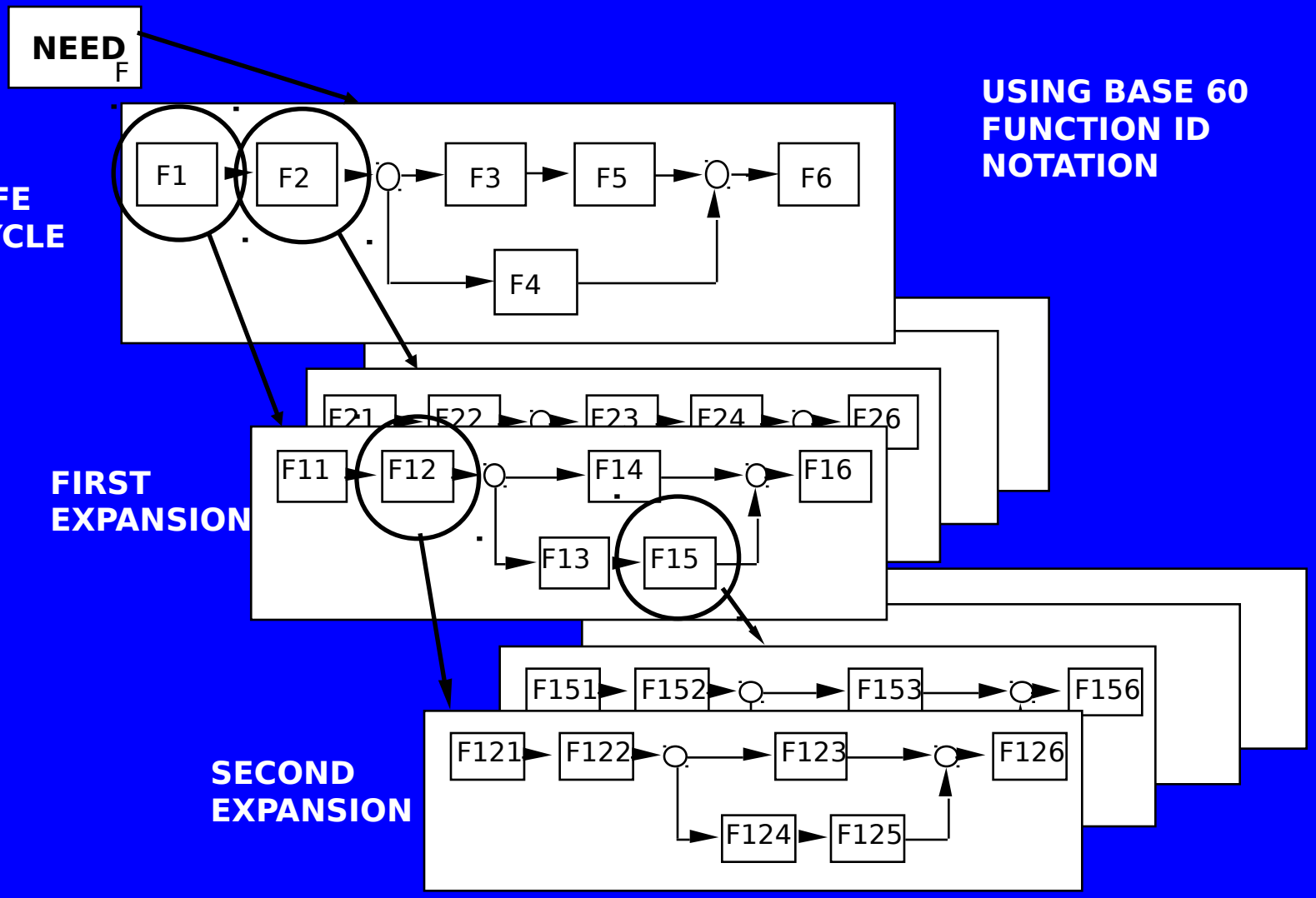
# Functional Flow Diagramming Levels





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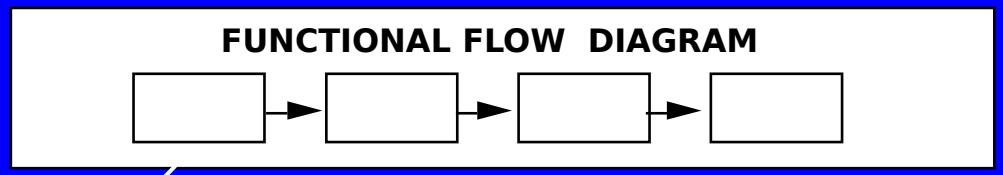
# Traditional Structured Analysis Summary

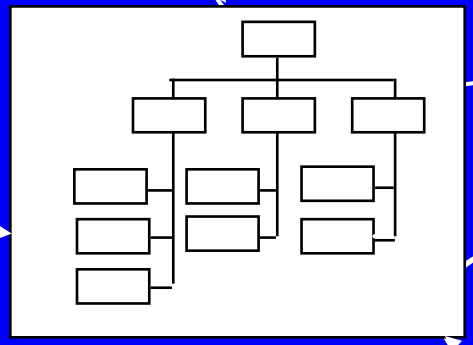



**F-A MATRIX**

FUNCTION TRANS-
FORMED INTO
PERFORMANCE
REQUIREMENTS
AND ALLOCATED
TO ARCHITECTURE

SYNTHESIZE THE
ARCHITECTURE

MANUFACTURING BREAKDOWN STRUCTURE
DRAWING BREAKDOWN STRUCTURE
WORK BREAKDOWN STRUCTURE
INTERFACE ANALYSIS
MAKE-BUY PLAN/PROCUREMENT
CONFIGURATION ITEM ANALYSIS
SPECIFICATION TREE DEVELOPMENT
TEAM/PRINCIPAL ENGINEER ASSIGNMENT



CONSTRAINTS ANALYSIS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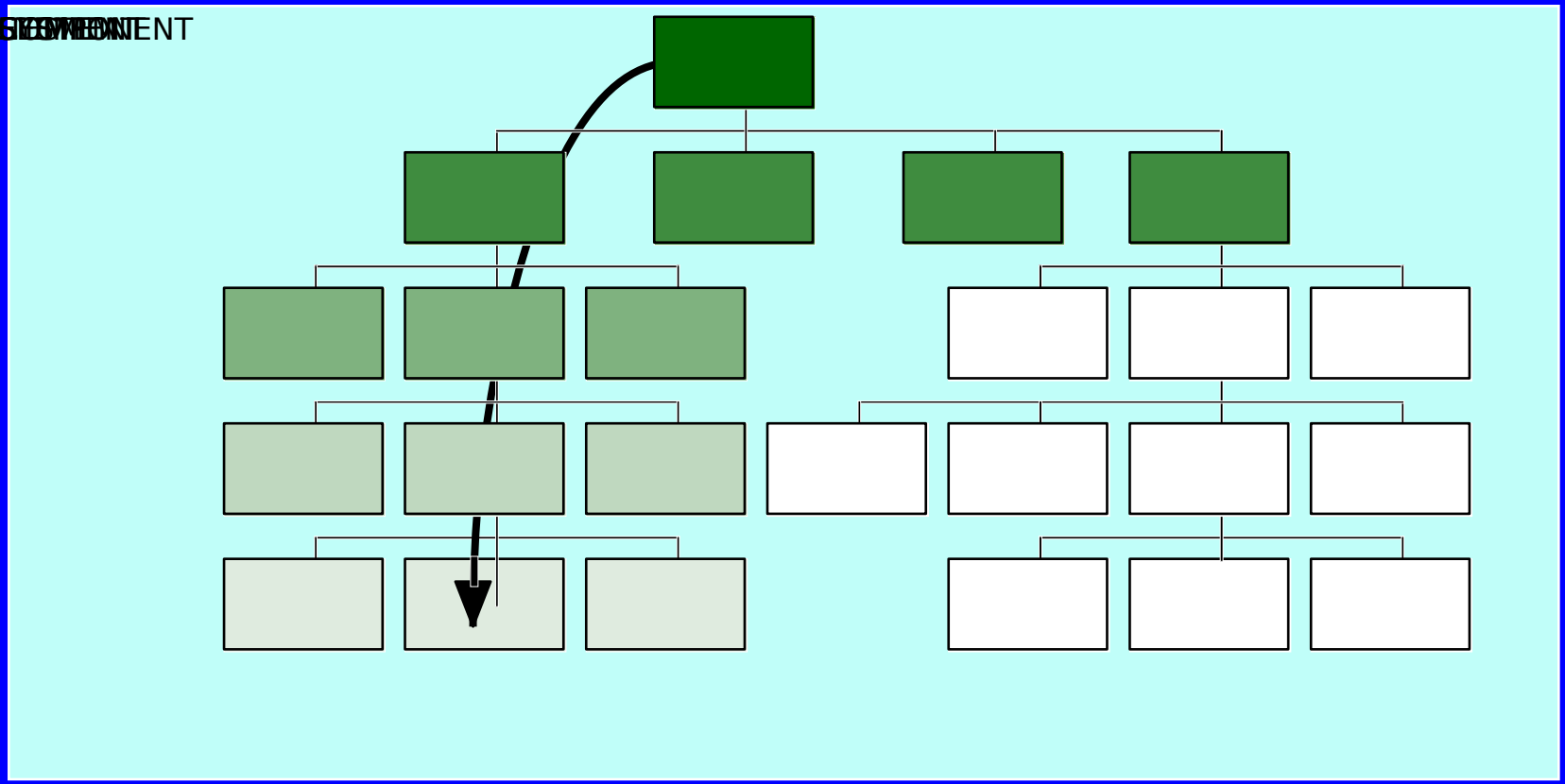
# Who Does the Structured Analysis Work?

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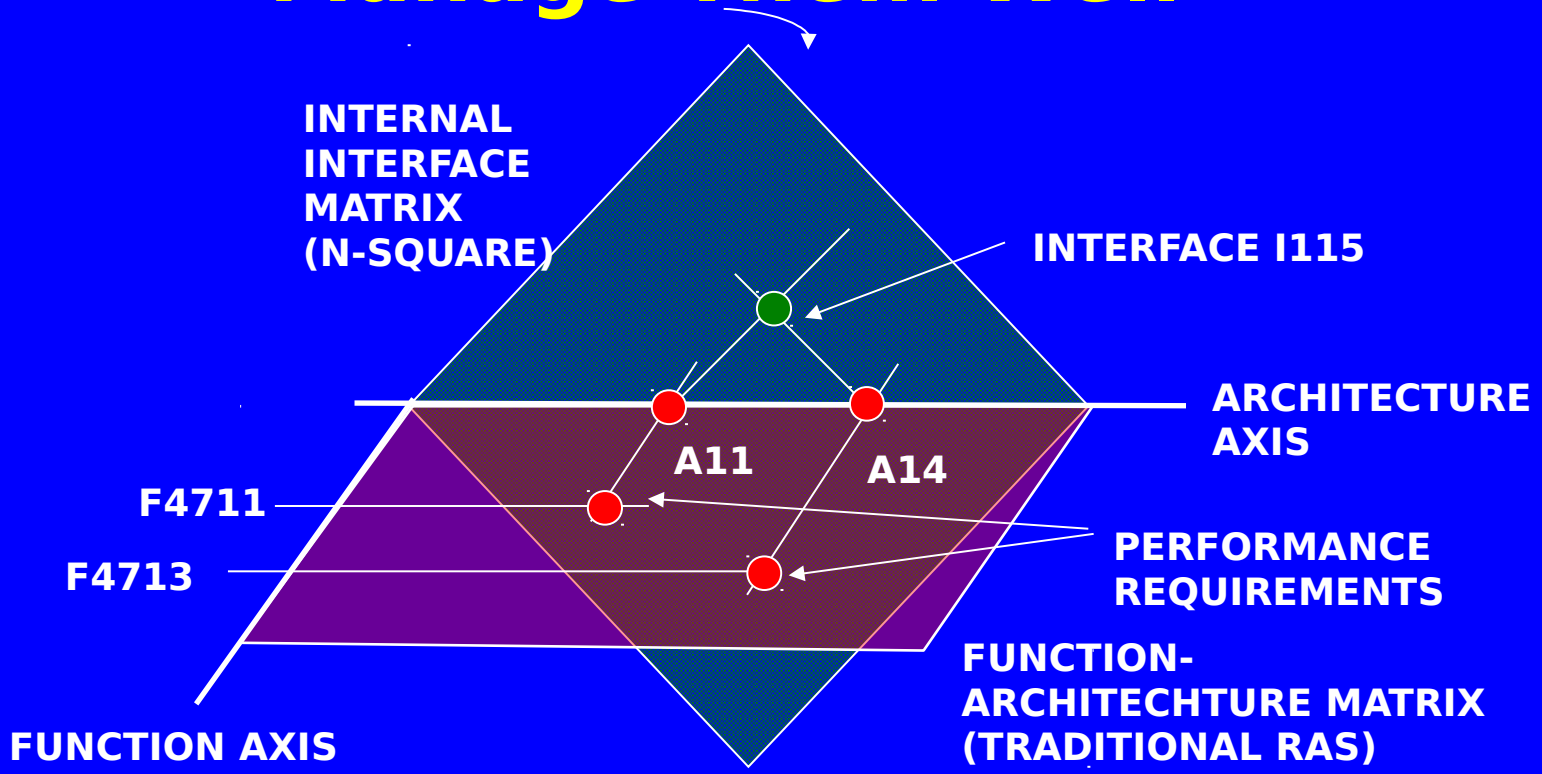
# Understand the Source of Needed Interfaces and Manage Them Well





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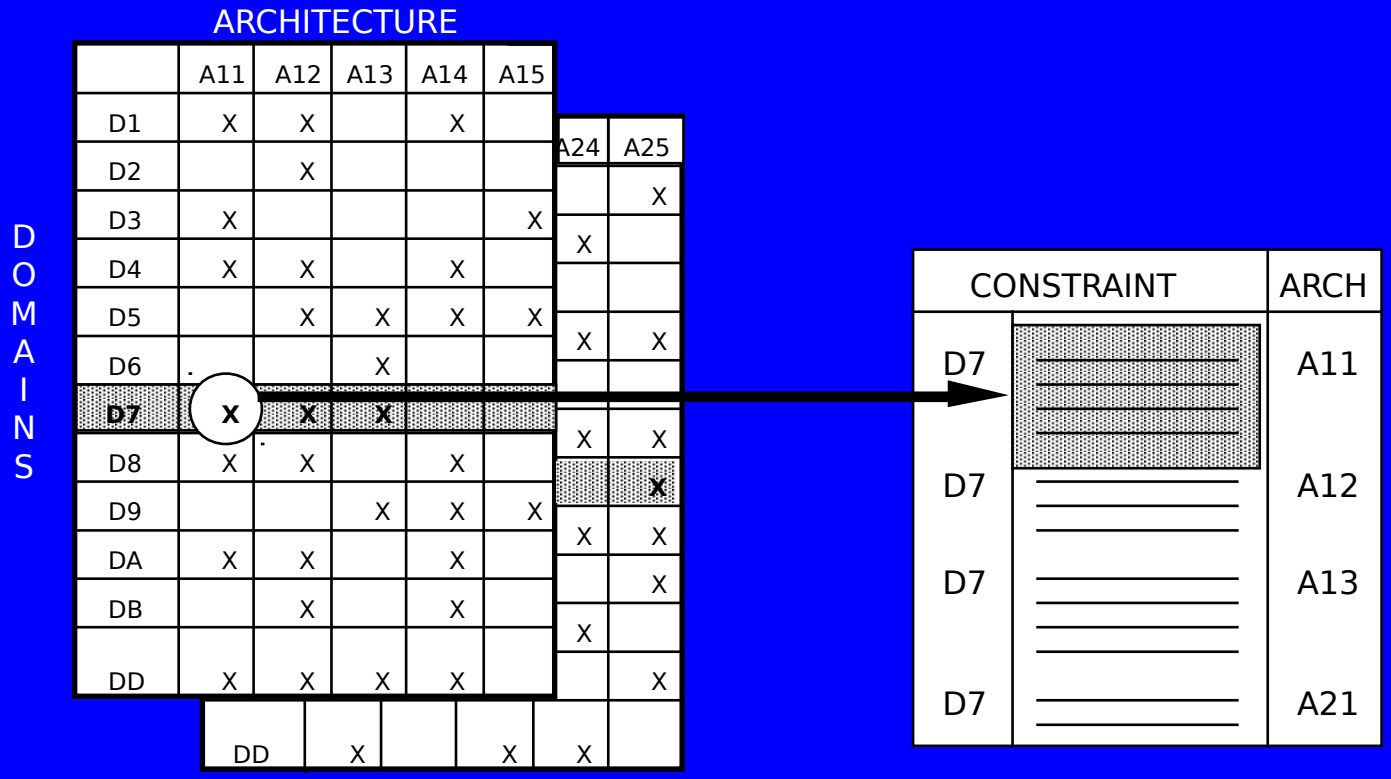
# Systematic Identification of Specialty Engineering Constraints




ARCHITECTURE-SPECIALTY ENGINEERING MATRIX
(DESIGN CONSTRAINTS SCOPING MATRIX)

SPECIALTY ENGINEERING REQUIREMENTS
FLOW INTO THE INDICATED SPECIFICATIONS

**Motivated by AFSCM-375 Series**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# Recognize the Complete Set of Environmental Stresses

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# Environmental Requirements Analysis Algorithm

- System environmental requirements
  - Define system spaces
  - Select standards covering those spaces
  - Delete unnecessary requirements
  - Tailor remaining parameter ranges
- End item environmental requirements
  - Map end items to process steps
  - Define process step environments
  - Integrate multiple process step differences
- Component environmental requirements
  - Zone end item and define zone environments
  - Map components to zones


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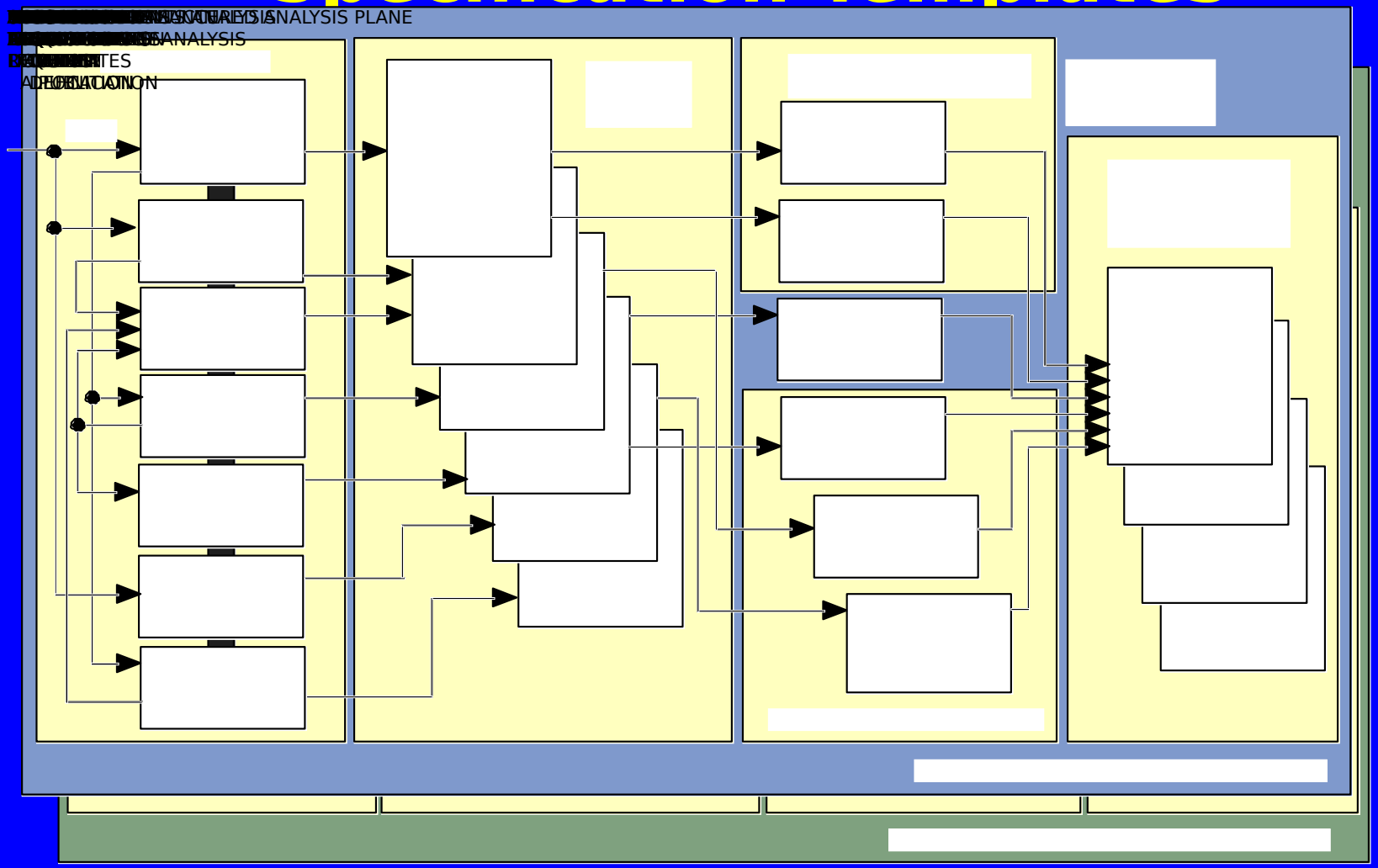
# Link Structured Analysis to Specification Templates

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# MIL-STD-961E Specification Structure
# Systems and Hardware Template

| PARA | TITLE | ANALYTICAL METHOD |
|---|---|---|
| 3 | Requirements | N/A |
| 3.1 | Functional and Performance Rqmts | N/A |
| 3.1.1 | Missions | Mission analysis |
| 3.1.2 | Threat | Threat analysis |
| 3.1.3 | Required States and Modes | Traditional structured analysis |
| 3.1.4 | Entity Capability Requirements | Traditional structured analysis |
| 3.1.5 | Reliability | Reliability math model |
| 3.1.6 | Maintainability | Maintainability math model |
| 3.1.7 | Deployability | Traditional structured analysis |
| 3.1.8 | Availability | Availability math model |
| 3.1.9 | Environmental Conditions | Standards, EUP, Zoning |
| 3.1.10 | Transportability | Traditional structured analysis |
| 3.1.11 | Materials and Processes | Boilerplate |
| 3.1.12 | Electromagnetic Radiation | Standards |
| 3.1.13 | Nameplates and Product Markings | Boilerplate |
| 3.1.14 | Producibility | Boilerplate |
| 3.1.15 | Interchangeability | Boilerplate |
| 3.1.16 | Safety | Standards |
| 3.1.17 | Human Factors Engineering | Standards |
| 3.1.18 | Security and Privacy | Standards |


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# Computer Software Structured Analysis Models

- Process-oriented analysis
  - Flow charting
  - Yourdon-Demarco
  - Hatley-Pirbhai
- Data-oriented analysis
  - Table normalizing
  - IDEF-1X
- Object-oriented analysis
  - Early models
  - UML


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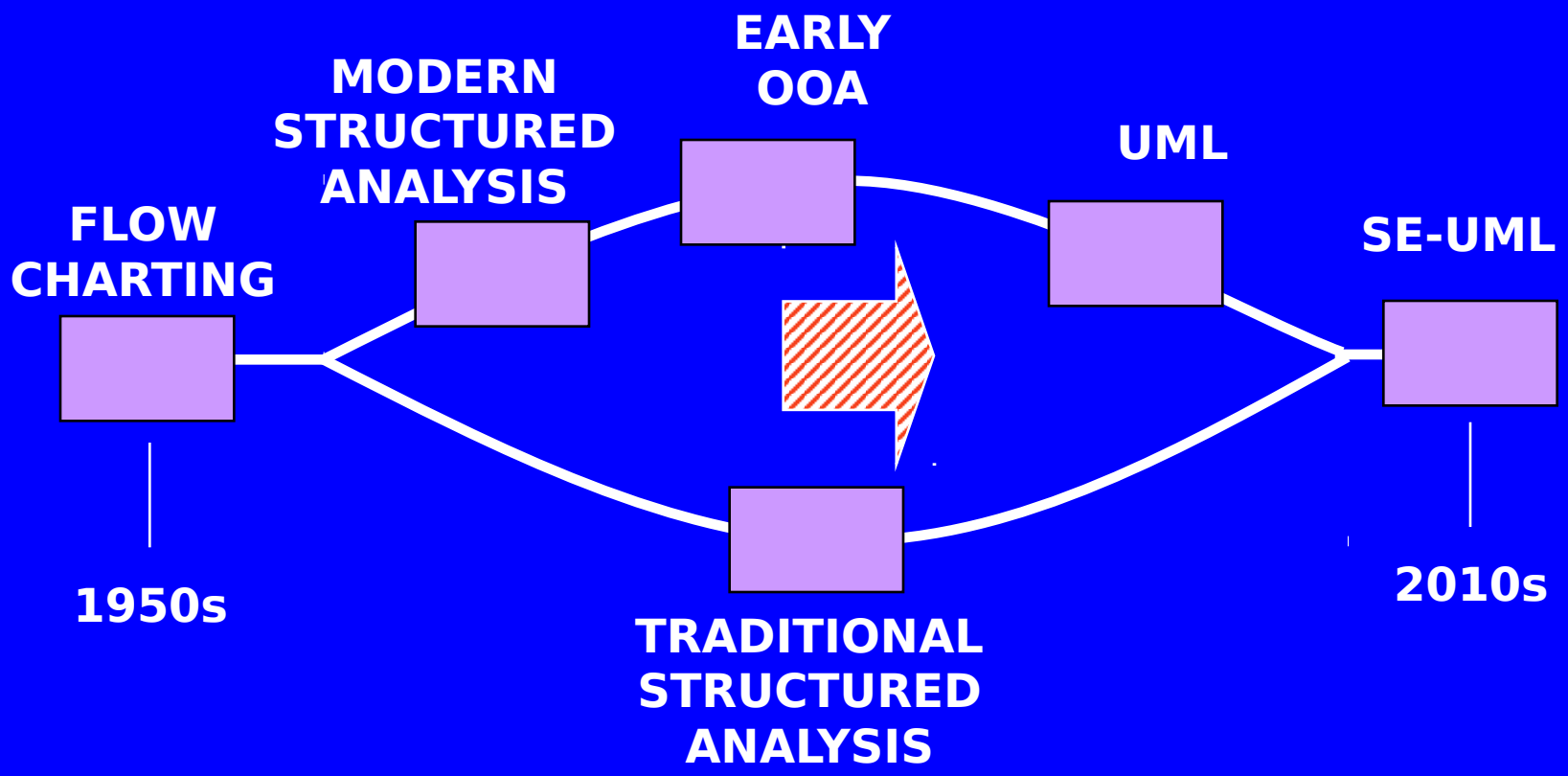
# Structured Analysis Pathways





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# UML and TSA Compared
# The Future Revealed

## UNIFIED MODELING LANGUAGE (UML)

<table>
<tr><td colspan="3">STATIC MODELING</td><td colspan="5">DYNAMIC MODELING</td></tr>
<tr><td rowspan="2">DEPLOY-<br>MENT<br>DIAGRAM</td><td rowspan="2">COMPONENT<br>DIAGRAM</td><td rowspan="2">OBJECT<br>& CLASS<br>DIAGRAMS</td><td rowspan="2">STATE<br>CHART</td><td colspan="2">INTERACTION DIAGRAMS</td><td rowspan="2">USE<br>CASE<br>DIAGRAM</td><td rowspan="2">ACTIVITY<br>DIAGRAM</td></tr>
<tr><td>COLLABOR-<br>ATION<br>DIAGRAM</td><td>SEQUENCE<br>DIAGRAM</td></tr>
<tr><td colspan="3">ARCHITECTURE<br>BLOCK DIAGRAM</td><td>STATE<br>DIAGRAM</td><td>SCHEMATIC<br>BLOCK<br>DIAGRAM</td><td>TIMELINE<br>DIAGRAM</td><td colspan="2">FUNCTIONAL<br>FLOW<br>DIAGRAM</td></tr>
<tr><td colspan="3">PHYSICAL<br>FACET</td><td colspan="2">BEHAVIORAL<br>FACET</td><td>TIME<br>FACET</td><td colspan="2">FUNCTIONA<br>L FACET</td></tr>
</table>

## TRADITIONAL STRUCTURED ANALYSIS (TSA)


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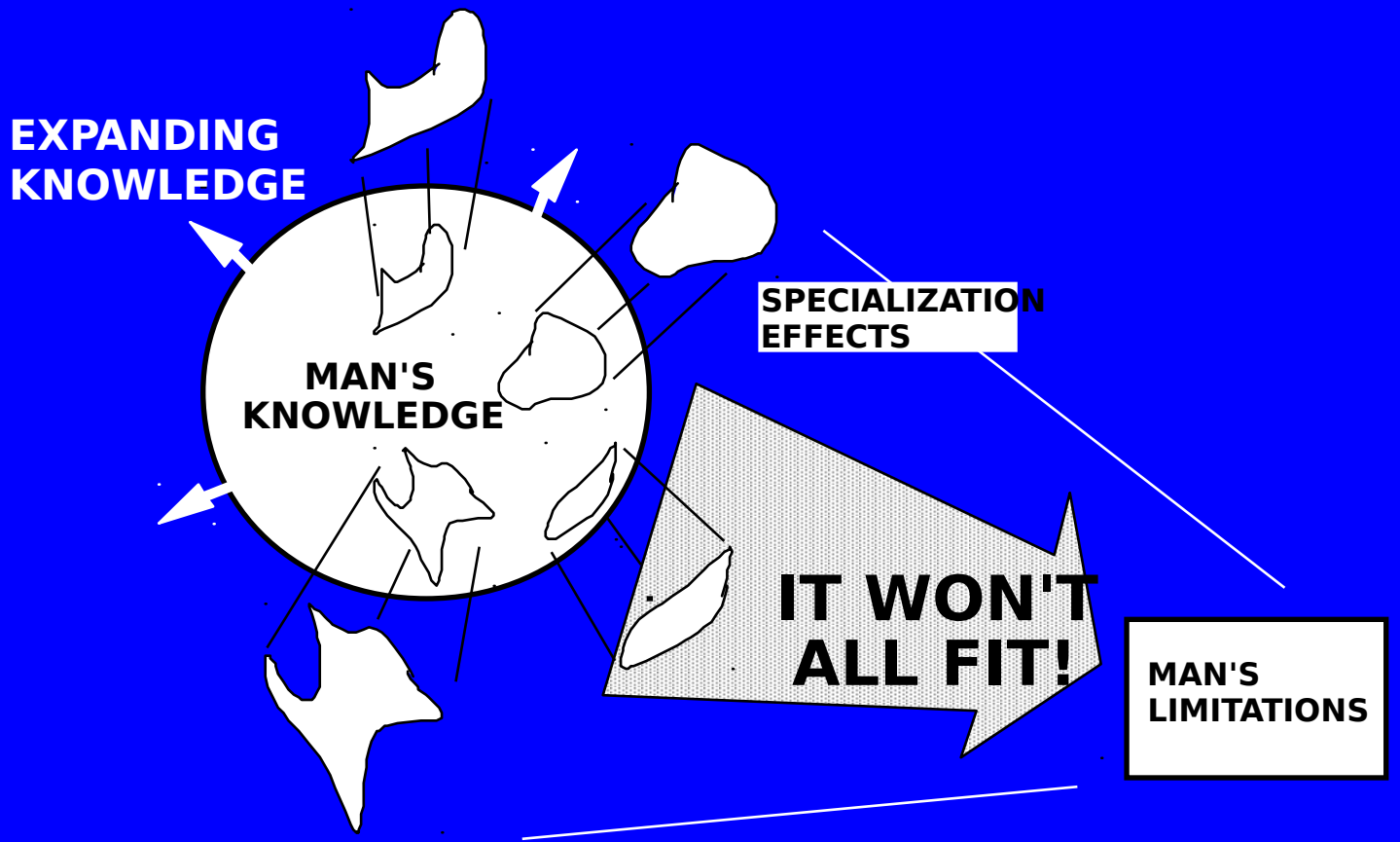
# The Basis For Everything We Do in System Engineering





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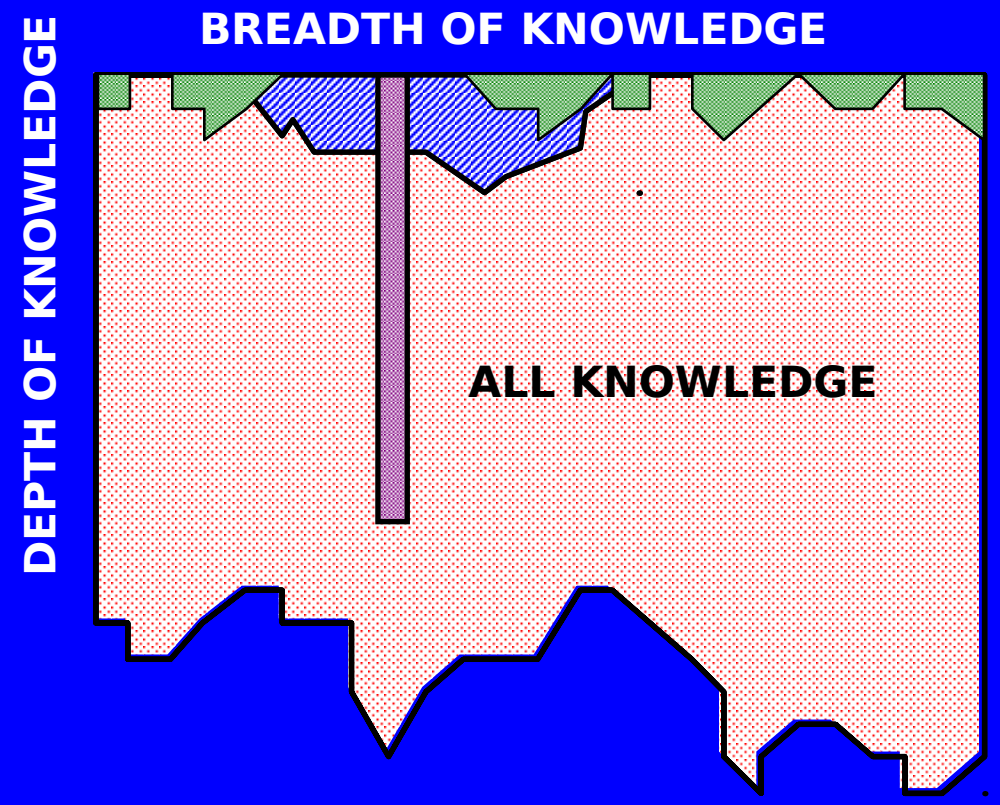
# We Are All Specialists - a Partial Solution





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# Physically Collocate to Recognize the Most Efficient Communication Media

**HUMAN COMMUNICATIONS - WORST INTERFACE ON PLANET EARTH!!**


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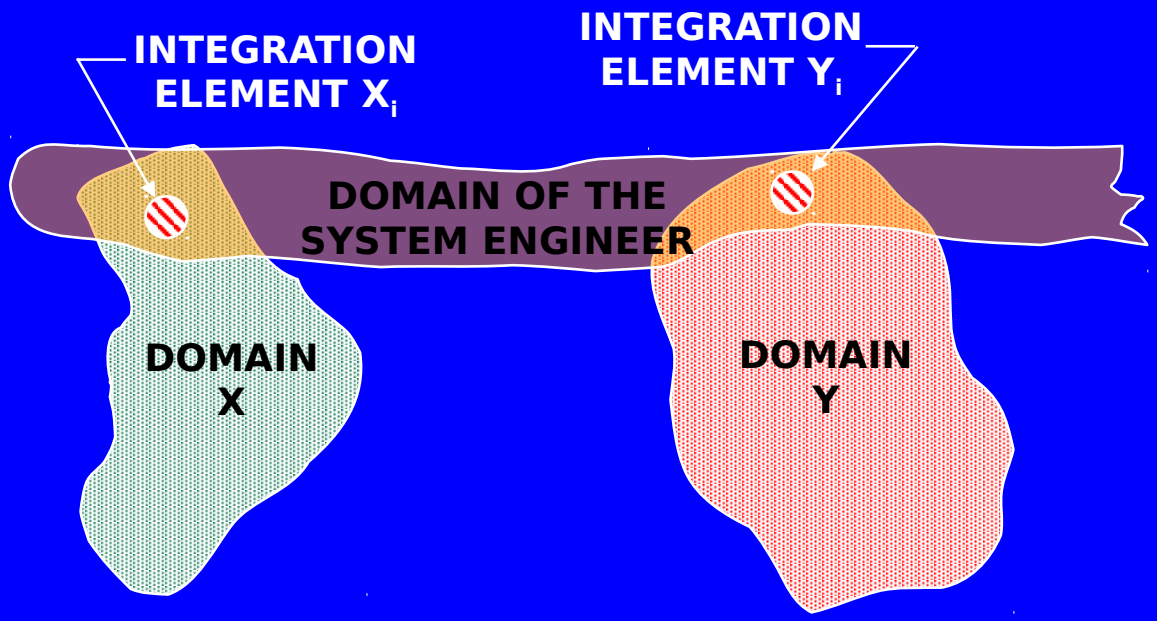
# Integration Skills





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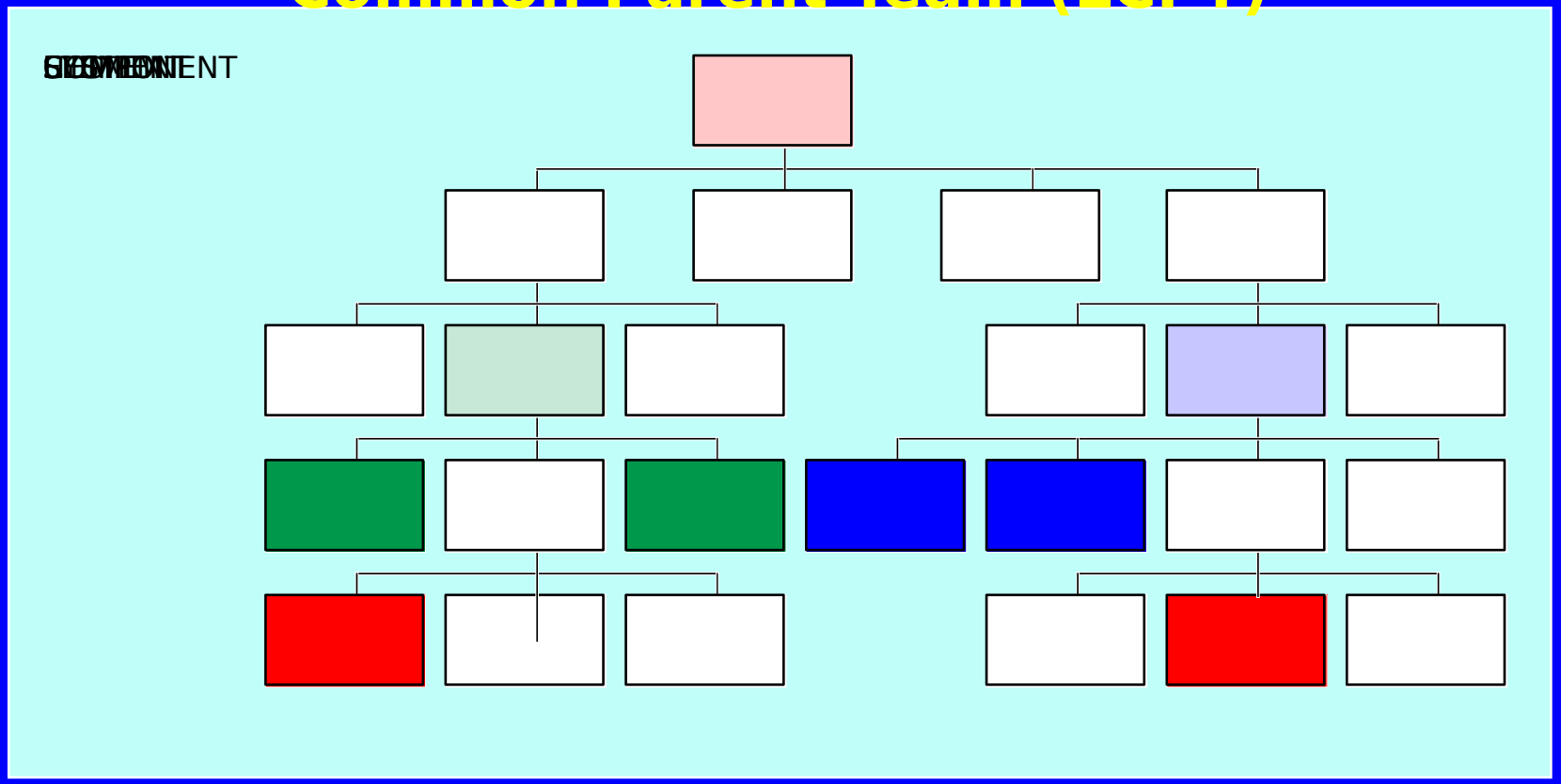
# Integration Agent Identification

## Interface Integration and Lowest Common Parent Team (LCPT)

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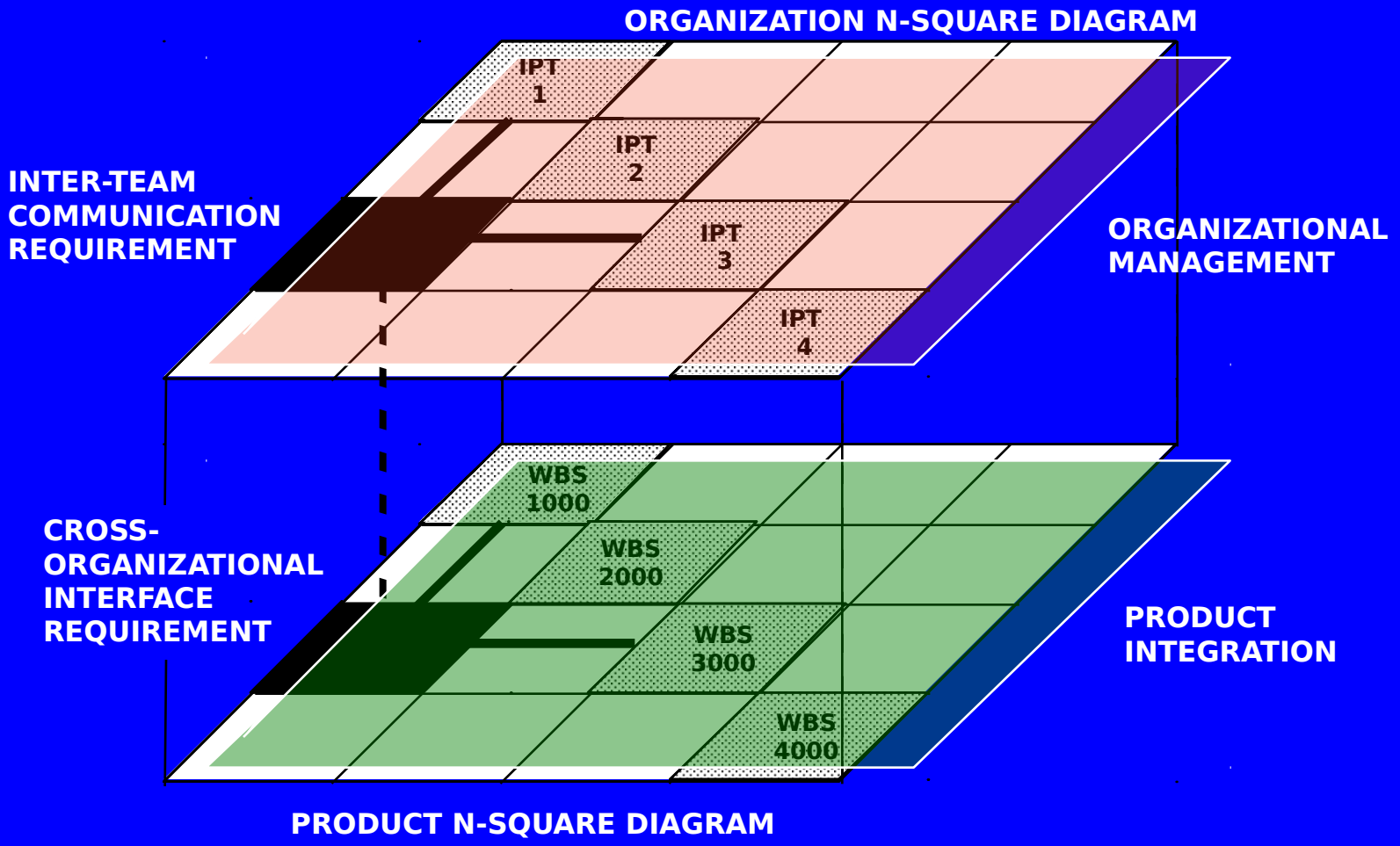
# The Most Powerful Way to Organize on a Program





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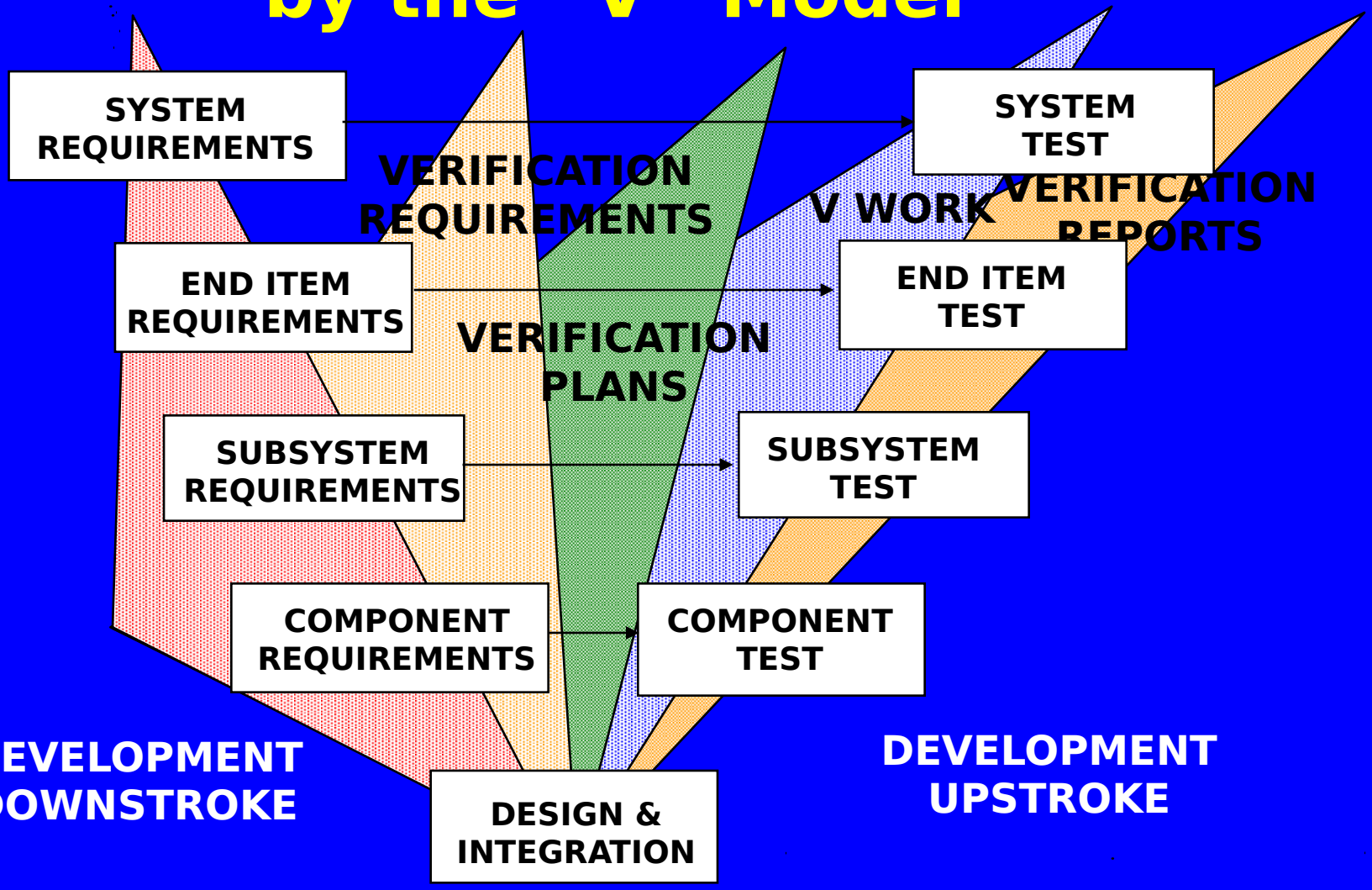
# The Powerful Message Offered by the "V" Model





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# Verification Atomic Structure

Table 4-1 Verification Traceability Matrix

| SECTION 3 PARA | TITLE | METHOD | SECTION 4 PARA |
|---|---|---|---|
| 3.5.6.3 | Transmitter Power | Test | 4.3.24 |

Verification String

- Link specification part 3 to method and part 4 verification requirements content to form strings
- Allocate verification strings to verification tasks
- Collect strings about these tasks
- Assign task responsibility
- Plan tasks
- Implement tasks on schedule
- Report results and collect these reports
- Form a judgment about report content


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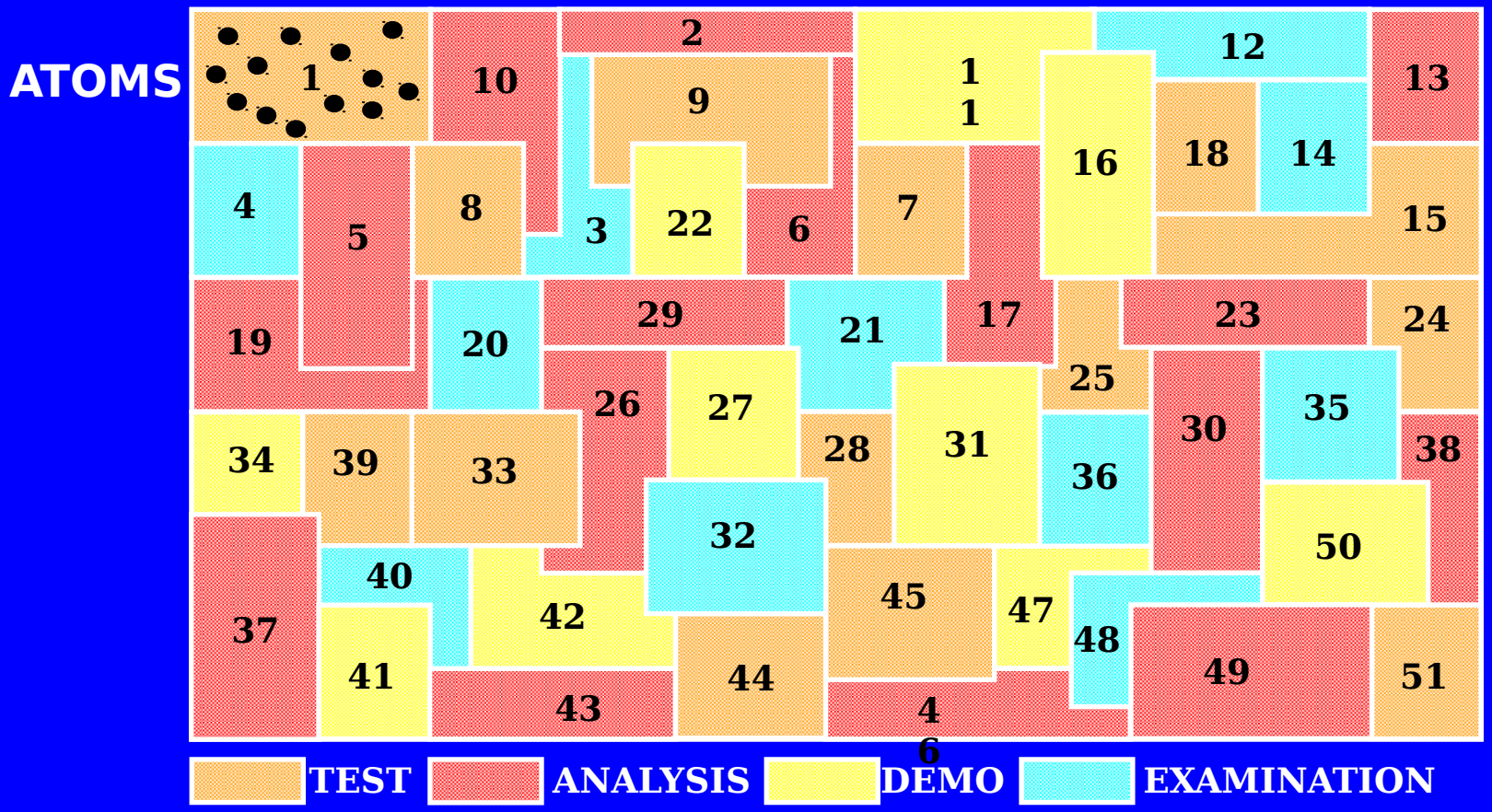
# Transformation of Requirements Into Tasks (Molecules of Work)





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# Verification Tracking Matrices

VERIFICATION DESIGN HAPPENS HERE

VERIFICATION COMPLIANCE MATRIX

INCLUDES EVERY VERIFICATION STRING

UNION OF MATRICES

TASK ONLY SCREEN

ITEM ONLY SCREEN

SPECIFICATION VERIFICATION TRACEABILITY MATRICES

VERIFICATION ITEM TRACKING MATRIX

VERIFICATION TASK TRACKING MATRIX

INCLUDES EVERY VERIFICATION TASK EACH OF WHICH IS COMPOSED OF MULTIPLE STRINGS


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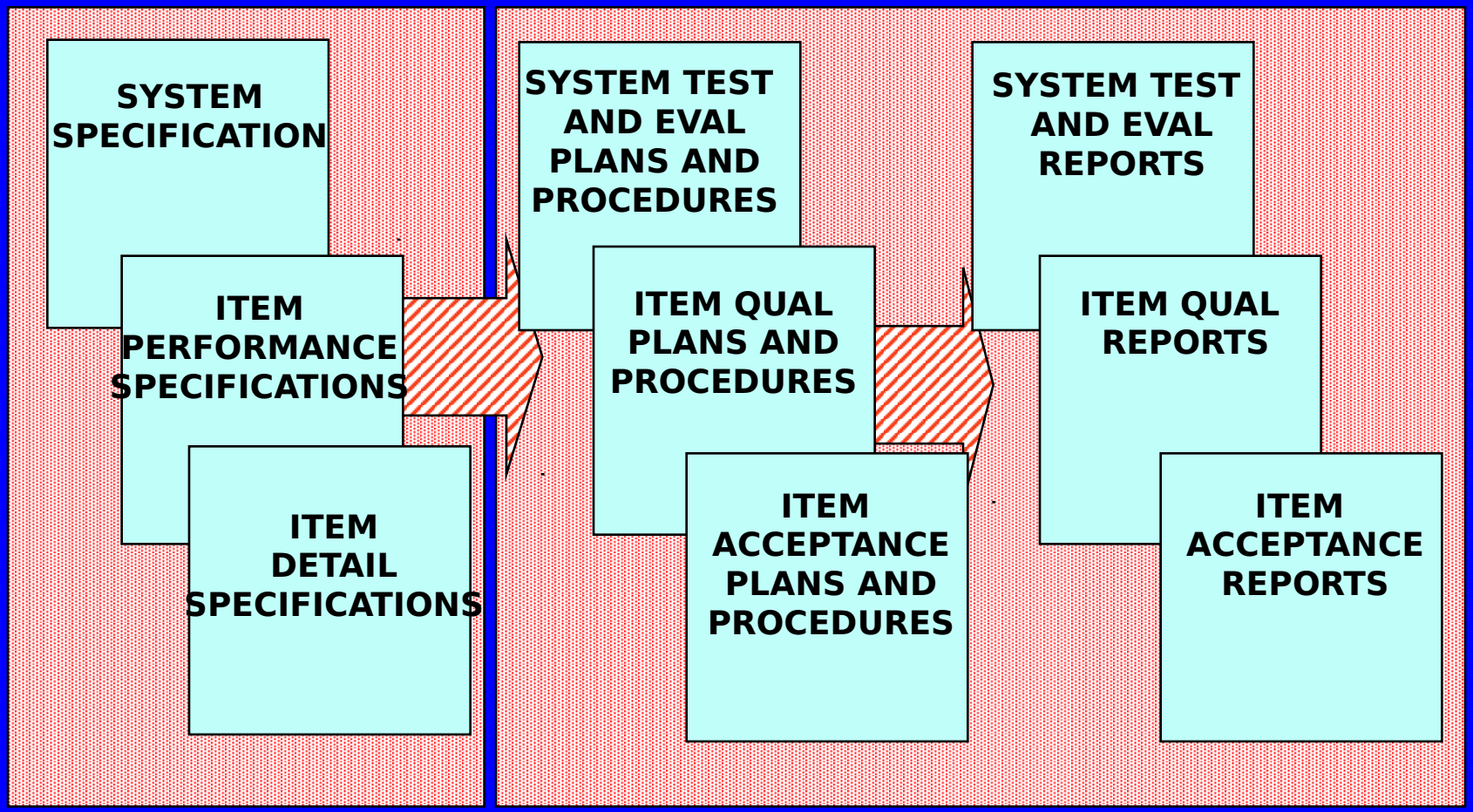
# Verification Documentation Pattern


SYSTEM SPECIFICATION
ITEM PERFORMANCE SPECIFICATIONS
ITEM DETAIL SPECIFICATIONS
SYSTEM TEST AND EVAL PLANS AND PROCEDURES
ITEM QUAL PLANS AND PROCEDURES
ITEM ACCEPTANCE PLANS AND PROCEDURES
SYSTEM TEST AND EVAL REPORTS
ITEM QUAL REPORTS
ITEM ACCEPTANCE REPORTS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# Road to Success

- Define the problem
- Synthesize a solution
  - Engineering design
  - Acquisition of material
  - Manufacturing
- Prove that the solution satisfies the requirements
- Accomplish all three steps within the context of a sound management infrastructure


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